proposed mounting of antennas with respect to the guardhouse and the traffic lanes. The distance from the antenna to the traffic lanes appears to be less than 15 feet.

8. I have also reviewed the Part 15 equipment authorization application submitted by AMTECH for its Model XI1400-AI1400 Portable Reader (FCC ID# FIHXI1400-AI1400), which transmits in the 2435-2465 MHz band but otherwise appears to serve exactly the same purpose as the AMTECH 902-928 MHz units. According to the material describing the XI1400-AI1400, it has a rated RF output power of 5 milliwatts, and a typical working range of 5 meters. Thus, both the 902-928 MHz unit and the 2435-2465 MHz unit appear to have about the same range requirement. There are some minor differences between the units. The 902-928 MHz unit is normally used with an antenna that supplies an additional 6 dB to 11 dB gain. The 2435-2465 MHz unit is used with an antenna that supplies a gain of 8 dB. The path loss at 2450 MHz is greater than the path loss at 915 MHz. The equation for path loss is:

$$L = 92.4 + 20 \log f + 20 \log d$$

where f is frequency in GHz and d is distance in kilometers. Thus, the path loss at 915 MHz is 8.5 dB less than the path loss at 2450 MHz. Based on the fact that the 2435-2465 MHz unit appears to operate with only 5 milliwatts, and the higher path loss at 2450 MHz, I

conclude that the 902-928 MHz unit should not require 2 watts of output power for most installations, and in fact, may work properly with only 5 to 10 milliwatts of output power.

9. According to an AMTECH data sheet, the International Standards Organization's Draft Standard for Automatic Identification of Freight Containers specifies a range of 13 meters. Using a distance-squared propagation law, this would justify a power increase of 6.8 over the power needed for a 5 meter range. If 5 milliwatts is sufficient for 5 meters, then 34 milliwatts should be sufficient for 13 meters.

10. According to AMTECH, the 902-928 MHz RF Module power level can be reduced at the time of installation, but this is done only if tagged objects beyond a specific distance must be ignored. For example, this would prevent detection of tagged objects passing close to a gate but not through a gate, or would detect an object passing through one particular gate in an array of gates. (AMTECH Supplemental Information for 47 CFR 90.239d at p.5.)

11. I believe that Section 90.239 of the FCC Rules requires that systems such as AMTECH'S must be limited to 250 milliwatts of output power. The AMTECH system is a sign post or proximity sensing approach to vehicle location determination. According to the Commission's 1974 Report and Order adopting rules for vehicle monitoring systems

(R&O in Docket No. 18302, 30 RR2d 1665), there are three approaches to acquiring location data: proximity sensing, multilateration and dead reckoning. Id. at para. 7. The description of proximity sensing clearly applies to AMTECH:

> "Vehicles are located by their proximity to fixed posts (sign posts) . . . A variation of this technique employs coded arrays . . . and the code of the array is communicated from the vehicle via narrow band data link." Id.

In the case of AMTECH, the coded array is within the tag and the narrow band data link is the reflected transmission from the tag to the reader. Since the AMTECH system is therefore a sign post type of system, it should be subject to the 250 milliwatt output power limit specified in Section 90.239(e)(3). Moreover, this subsection provides that sign post systems are secondary to "regular co-channel operations" such as wideband pulse ranging systems.

12. At least some of the 1309 AMTECH installations are licensed to use and actually operate at 2 watts output power. These do not comply with the 250 milliwatt limit in Section 90.239(e)(3) and do not comply with the general requirement in the Commission's Rules that "applications for authorizations must specify no more power than the actual power necessary for satisfactory operation." 47 CFR 90.205.

13. To correct this problem and preserve spectrum resources, I believe future license applications should be required to contain a showing that the power level

specified in the application complies with these requirements

Duty Cycle.

14. From the material I have reviewed, it appears that the 902-928 MHz Model AR2200 transmits continuously. For example, an AMTECH information sheet describes the tags as devices that retransmit "continuous radio wave signals."

15. A message tag contains 128 bits of information. The bit rate of the reflected transmissions is 10,000 bits per second. A message, therefore, requires only 0.0128 seconds for transmission. (AMTECH Supplemental Information for 47 CFR 90.239d at p.7.) This suggests that the transmitter could be on for one-tenth of a second and off for nine-tenths of a second, or a 10% duty cycle which would suffice for slow-moving vehicles. For uses involving faster vehicles, a higher duty cycle could be employed. For example, for vehicles moving at 50 miles/hr., or 75 ft./sec., a reasonable duty cycle might be on for one-tenth of a second, then off for one-tenth of a second, or a 50% duty cycle. For optimal spectral efficiency, the duty cycle requirement should tailored to the actual use.

16. This continuous transmission unnecessarily pollutes the radio frequency environment. For some uses, such as the guardhouse gate at a residential neighborhood where vehicular traffic is sparse and slow-moving, it would be more spectrally efficient to operate with a lower duty

cycle than 100%. Another approach to reducing the duty cycle would be to install a photocell detector or an embedded loop in the pavement. The transmitter would be controlled so that it only transmits when an object is detected in its proximity.

17. Spectrum efficiency could be increased by adding conditions, such as the following, to future licenses: "Operation of this transmitter shall be automatically limited so that the duration of each transmission shall be no greater than necessary for satisfactory operation, and there shall be silent periods between such transmissions."

Channel Spacing.

18. For some uses, a number of AMTECH transmitters/receivers operate in close proximity to one another. In such cases, these units "must operate at frequencies separated by a minimum of 2 MHz." (AMTECH Supplemental Information for 47 CFR 90.239d at p.5.) This leads to a channel plan involving AMTECH transmitters every 2 MHz across portions of the 902-928 MHz band, making inefficient use of the spectrum because transmissions interfere with and thus preclude certain wideband uses of the spectrum.

19. I see no reason for the requirement imposed by AMTECH that transmitter frequencies be separated by at least 2 MHz. I would expect that a 300 kHz channel spacing would be fully satisfactory with affordable

reader/receivers, and this could be reduced if better quality filters were employed in the receivers. Although the initial signal is a CW signal at a single frequency, it is modulated in the tag by a 40 kHz frequency shift keyed signal. The Necessary Bandwidth for a 10 kbits/sec. data rate carried on such a signal, using the methods of Section 2.202 of the Commission's Rules, should be about 100 kHz. The receiver bandwidth, according to AMTECH, is 130 kHz. Id. The difference between this bandwidth and the calculated Necessary Bandwidth could be accounted for by inexpensive filters employed in the receiver.

20. If the tag transmitter is actually occupying a much greater bandwidth than 100 kHz, then it is using the spectrum inefficiently, and additional filtering should be added to the transmitter. Unfortunately, there is no requirement for equipment authorization and AMTECH, therefore, is not required to submit measurements. I cannot determine whether this is the cause of the extremely inefficient channel spacing.

21. AMTECH has deployed transmitter/receivers at only 1309 locations. These could easily be refitted with more efficient filters during routine maintenance, and retuned to frequencies closer together. The tags, while deployed in much larger numbers, are wideband in operation and do not need to be modified.

Polarization Isolation.

22. Cross-polarization isolation is a relatively common and inexpensive means to improve spectral efficiency. It is required for use with fixed transmitters in the microwave and satellite radio services. It does not appear that AMTECH employs any particular polarization for its fixed transmitters.

23. It should be possible for AMTECH to alternate the polarization of the fixed transmitters and fixed receivers when operating with multiple lanes of traffic, and this may reduce interference and thereby make it possible to narrow the 2 MHz channel spacing. It appears that no consideration has been given to this matter in the design of the AMTECH technology.

Frequency Stability.

24. The above-referenced Vintage Club license application specifies an emission designator of 20K00N0N. According to Section 2.201 of the Commission's Rules, NON corresponds to an unmodulated carrier and 20K00 corresponds to a bandwidth of 20 kHz. However, an unmodulated carrier has no bandwidth.

25. According to Technical Bulletin TB90.01 issued by AMTECH on October 10, 1990, the emission designator of 20K00NON "permits operation at ±10 ppm, or 10 kHz off the assigned frequency band to account for tuning and drift variables." This 10 ppm stability corresponds to a

frequency stability of 0.001%. This is far poorer than is required for other fixed communications transmission equipment operating around 900 MHz. The requirements range from 0.0001% up to 0.00001%, or ten times to 100 times more stable.

26. Since the technology to produce a higher stability is evidently readily available, good spectrum management practice suggests that it be employed unless it can be shown to be inappropriate.

Licensing or Equipment Authorization for Tags.

27. The reflector tags apparently are totally unregulated by the Commission. Neither licensing nor equipment authorization is required. The tags, however, are not merely passive reflectors. Rather, they are low power transmitters that receive an incoming RF signal, modulate it and retransmit it. The reflected signal has a different bandwidth than the incident signal.

28. In a similar situation involving microwave equipment, the Commission's Chief Scientist determined that the "receiver" was actually acting as a transmitter and required both an equipment authorization as a transmitter and licensing. See letter from Robert S. Powers, Chief Scientist, to Daniel Blattman, President, Racon Inc., June 11, 1985, regarding FCC ID# B2N9CL10050, and related correspondence. See also letter from Robert S. Foosaner, Chief, Private Radio Bureau, to Daniel Blattman, August 29,

1985, confirming that both ends of the transmission link must be licensed. Moreover, even totally passive RF reflectors that do not modify the signal are subject to licensing in some radio services. See, for example, Sections 94.45(a)(7) and 94.75(e) of the Commission's Rules.

29. I have reviewed the Association of American Railroads (AAR) Standard S-918-91 for Automatic Equipment Identification. This standard seems to be based on the AMTECH technology. Section 6.3 of that document specifies that the strength of the modulated signal transmitted by the tag shall be between 19,600 and 56,800 microvolts per meter at 5 meters. I believe tags conforming to this standard violate Section 15.249 of the Commission's Rules, which limits the field strength of emissions in the 902-928 MHz band by intentional radiators to 50,000 microvolts per meter at 3 meters.

30. The AMTECH tags apparently operate across the 850-950 MHz range. Any incoming signal within this range is modulated and reflected. It is not clear what happens when a tag enters the RF field of a mobile radio or paging transmitter operating in this band. However, if we assume that these tags respond to incident fields as specified in the AAR standard, then it would appear highly likely that such tags would generate impermissible signal levels when in the vicinity of land mobile transmitters. It is not

clear whether there is any chance of interference resulting, particularly due to the battery-powered tags. In light of this, it would seem appropriate for the Commission to impose some form of regulation, either licensing or equipment authorization, on the tags, in order to assure that they can not cause harmful interference to licensed operations.

31. An equipment authorization requirement could help to improve the security of the AMTECH system. As the system is now designed, there is no security against counterfeit, "cloned" tags. An enterprising pirate could manufacture and sell cloned tags as a way to cheat the highway toll collection services. The Commission is well aware of the financial incentives that lead to such behavior. (Second Report, Inquiry Into Home Satellite Dish, Gen. Dkt. No. 86-336, Feb. 25, 1988.) An equipment authorization requirement would make this practice illegal.

32. It is my belief, as stated above, that the AMTECH RF Identification system does not make efficient use of the radio spectrum. In order to remedy this condition, the FCC should impose specific conditions that limit the output power, duty cycle, channel spacing, and frequency stability

in addition to regulating the low power transmitters called "tags."

Date: 8/6/92 Signed: Jeffrey Krauss
Jeffrey Krauss

Subscribed and sworn before me this 6th day of August, 1992.

Notary Public

My Commission expires: My Commission Expires February 28, 1994.

B

BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C.

In the Matter of	)	
	)	
Amendment of Section 90.239	)	
of the Commission's Rules to	)	RM No. 8013
Adopt Permanent Regulations for	)	
Automatic Vehicle Monitoring	)	
Systems	)	

AFFIDAVIT OF RICHARD L. SCHMALENSEE

Commonwealth of Massachusetts	)	
County of Middlesex	)	ss:
	)	

RICHARD L. SCHMALENSEE being duly sworn, deposes and says:

1. I am the Gordon Y Billard Professor of Economics and Management at the Massachusetts Institute of Technology in Cambridge, Massachusetts, and Director of MIT's Center for Energy and Environmental Policy Research. I received my Ph.D. in Economics from MIT in 1970. I have done extensive research, writing and teaching in the areas of industrial organization and of competition and regulatory policy. A good deal of my work has focused on non-price competition and conditions of entry.

2. I served as a member of President Bush's Council of Economic Advisors between 1989 and 1991. I had primary responsibility for domestic and regulatory policy, including telecommunications. Earlier, I served for several years as a consultant to the Bureau of Economics of the Federal Trade Commission. I have served on the editorial boards of several leading economics journals, including the American Economics Review, the Journal of Industrial Economics and the International Journal of Industrial Organization. I was elected a Fellow of the Econometric Society in 1982, am a Research Associate of the National Bureau of Economic Research, and have been nominated to be a Member of the Executive Committee of the American Economic Association. Various books and articles I have written deal with issues of competition policy, including issues related to conditions of entry. My curriculum vitae is attached hereto.

3. I have reviewed the Petition for Rulemaking filed by North American Teletrac and Location Technologies, Inc. ("Teletrac"), requesting the Commission to adopt permanent rules governing Automatic Vehicle Monitoring ("AVM") systems operating in the 904-912 MHz and 918-926 MHz bands. I have also reviewed the oppositions to the Petition filed by Pinpoint Communications, Inc.

("Pinpoint"), AMTECH Corporation ("AMTECH"), Southwestern Bell Corporation ("SBC"), and Mark IV IVHS Division ("Mark IV").

4. In their oppositions, Pinpoint and AMTECH claim that the co-channel separation proposal advanced by Teletrac will unnecessarily restrict competition by creating a duopoly. However, as discussed below, their arguments do not establish that Teletrac's proposal would produce duopoly in any economic sense. Moreover, as also discussed below, an "open entry" regulatory regime of the type that AMTECH and Pinpoint suggest would inhibit innovation, entry and investment in the AVM market and would thus tend to restrict competition and reduce consumer benefits. Other arguments advanced in opposition to Teletrac's proposal lack economic merit.

5. Pinpoint and AMTECH appear to argue that Teletrac's proposal to continue licensing only wideband pulse-ranging systems in the 904-912 MHz and 918-926 MHz bands would create a "duopoly" consisting of Teletrac and one other wideband licensee, since each would have control over one of the two 8 MHz wideband channels. But an economically meaningful duopoly exists if and only if a supplier of a good or service faces only one competitor. As Pinpoint's own opposition acknowledges, there are other

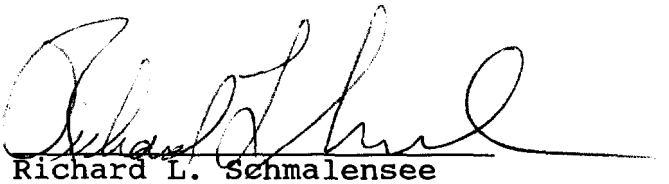
competitors in the AVM market: Lo-Jack, Trimble and numerous other firms provide various types of AVM services, in a variety of frequency bands. Moreover, nothing in the proposed rulemaking prevents Pinpoint, AMTECH or any other firm from developing and marketing new technologies for wideband or narrowband systems or developing entirely new AVM services. Contrary to Pinpoint's and AMTECH's assertions, therefore, Teletrac's proposal would foster a competitive AVM marketplace.

6. Pinpoint, AMTECH, SBC, and Mark IV IVHS also argue for continued band sharing to keep the AVM market "free and open." Band sharing can, of course, be a valuable technique for spectrum management in some situations in which interference is not of great economic significance or in which detailed standard-setting (designed to prevent interference) has relatively low economic cost. But keeping the 902-928 MHz band "free and open" appears likely to increase the production of interference that makes it impossible to locate vehicles reliably using existing technology. When and where this occurs, the value of investments in AVM systems would be significantly reduced. The prospect of having significant investments subject to this sort of risk must inevitably reduce the incentive to invest in the AVM marketplace. It

will be very difficult to attract capital to this market as long as a licensee must face the constant threat of economically catastrophic interference. Thus, the "open entry" advocated by Pinpoint and AMTECH would significantly discourage the large-scale investment in the use of AVM technology that is necessary to produce either competition or consumer benefits. Failure to adopt co-channel separation may itself prevent the emergence of a competitive market.

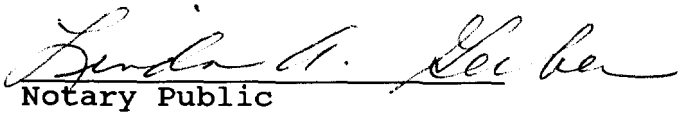
7. Other arguments advanced in opposition to the Teletrac Petition lack economic merit. AMTECH, which does not claim to compete with Teletrac or other location services, seems simply to want the spectrum at issue for its own use. Pinpoint, which has no customers or licenses and has done no field tests, asks the Commission to preserve "open entry" in the name of innovation. Nothing in Teletrac's proposal limits Pinpoint's ability to innovate. Indeed, by furthering the development of a competitive AVM marketplace, Teletrac's proposal is likely to increase the value of any genuine innovations Pinpoint may produce. SBC and Mark IV ask for a time-consuming examination of a wide range of issues, including the channel plan that has been in force since 1974 and that has shaped Teletrac's and others' investments in the AVM

marketplace. The Commission must recognize that delaying adoption of permanent rules that deal adequately with interference is a decision that will deprive consumers of benefits they can have today. Choice cannot be avoided because delay is not free: in deciding whether to act, the Commission is in effect choosing between speculative claims of increased future benefits and present real benefits to consumers.



Richard L. Schmalensee

Subscribed and sworn to before me
this 5th day of August 1992.



Notary Public

My commission expires: April 18, 1997.

CURRICULUM VITAE

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EDUCATION:

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
S.B., Economics, Politics and Science, 1965
Ph.D., Economics, 1970

EMPLOYMENT:

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

1991-	Director, Center for Energy and Environmental Policy Research
1988-	Gordon Y Billard Professor of Economics and Management
1986-	Professor, Department of Economics
1979-	Professor, Sloan School of Management
1977-79	Associate Professor, Sloan School of Management
1970	Assistant Professor, Sloan School of Management (Spring)
1967-69	Instructor, Sloan School of Management

PRESIDENT'S COUNCIL OF ECONOMIC ADVISORS

1989-91	Member
1967	Junior Staff Economist (Summer)

UNIVERSITY OF CALIFORNIA, SAN DIEGO

1974-77	Associate Professor, Department of Economics
1070-74	Assistant Professor, Department of Economics

VISITING APPOINTMENTS:

1985-86	Visiting Professor, Harvard Business School
1985	Visiting Professor, CORE, University of Louvain, Belgium (Spring)
1980-81	Visiting Scholar, Department of Economics, Harvard University
1973-74	Visiting Associate Professor and Research Fellow, Department of Economics, University of Louvain, Belgium

PROFESSIONAL ACTIVITIES:

Editorial Board: *Journal of Economics and Management Strategy* (1992-)
Associate Editor: *Journal of Economic Perspectives* (1992-)
Associate Editor: *Zeitschrift fur Nationalokonomie* (1987-89)
Associate Editor: *International Journal of Industrial Organization* (1982-89)
Board of Editors: *American Economic Review* (1982-86)

Editor (1978-89), Co-Editor (1989-): MIT Press Monograph Series, *Regulation of Economic Activity*
Associate Editor (1977-81), Board of Editors (1981-89): *Journal of Industrial Economics*

Nominating Committee, American Economic Association (1987)
Advisory Committee on Meetings Program, American Economic Association (1986, 1989)
Chairman: Local Arrangements Committee, Econometric Society World Congress (1985)
Fellow: Econometric Society (1982-)
Chairman: Program Committee, Econometric Society North American Fall Meeting (1980)
Program Committee, Econometric Society World Congress (1980)

Area Head: Economics, Finance, and Accounting; Sloan School of Management (1987-89)
Coordinator: Applied Economics Group, Sloan School of Management (1986-87)
Chairman: Doctoral Program Committee, Sloan School of Management (1982-85)

Research Associate, National Bureau of Economic Research (1992-)

Board of Directors, Long Island Lighting Company (1992-)
Special Consultant: National Economic Research Associates, Inc. (1981-89, 1991-)

Consultant, Bureau of Economics, Federal Trade Commission (1972-81)
Environmental Economics Advisory Board, U.S. Environmental Protection Agency, (1992-
Chairman: Clean Air Act Compliance Analysis Council, U.S. Environmental Protection Agency, (1992-)
Board of Directors, American Council for Capital Formation Center for Policy Research (1991-)

Donald Gilbert Memorial Lecture, University of Rochester (1992)

BOOKS WRITTEN:

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